July 5, 2019

Ex Parte Notification

Marlene H. Dortch, Secretary
Federal Communications Commission
445 12th Street SW
Washington, DC 20554

Re: Unlicensed Use of the 6 GHz Band, ET Docket No. 18-295
Expanding Flexible Use in Mid-Band Spectrum between 3.7 and 24 GHz, GN Docket No. 17-183

Dear Ms. Dortch:

On July 2, 2019, representatives from Apple Inc., Broadcom Inc., Cisco Systems Inc., Facebook, Inc., Google LLC, Hewlett Packard Enterprise, Intel Corporation, Marvell Semiconductor, Inc., Qualcomm Incorporated, and Ruckus Networks met with representatives of the Commission's Office of Engineering and Technology to discuss the technical viability of deploying low-power indoor ("LPI") operations throughout the 5.925 to 7.125 GHz ("6 GHz") band. A list of meeting participants is provided at the end of this letter.

The undersigned parties have explained that LPI unlicensed devices are a very important equipment class for American consumers, serving use cases that cannot easily be implemented via devices that require the use of an Automated Frequency Coordination ("AFC") system.[1] Also, many important indoor peer-to-peer use-cases requiring very-high-throughput links do not need a connection to the Internet or an AFC system. Moreover, significant building attenuation will limit the ability of a consumer access point to obtain its geolocation information and thus unnecessarily prohibit a key low-power use case that presents no real-world risk of harmful interference to licensed FS operations. On the other hand, an AFC system will work exceptionally well for standard power unlicensed equipment because such equipment is not as cost sensitive and is more likely to be deployed via a managed network that can readily accommodate AFC and geolocation tools.

During the meeting, the industry participants presented the attached slide deck containing an interference protection case study of the 6 GHz Fixed Service ("FS") links licensed to the Los Angeles Department of Water and Power ("LADWP"). The interference protection analysis demonstrates that the potential interference from unlicensed LPI operations to any LADWP FS link is extremely unlikely even when an unlicensed device is operating within direct line of sight of a licensed FS link. LADWP's 152 FS links were analyzed in stages. First, an I/N analysis was performed. This was followed by a more detailed C/I analysis of those links that could potentially exceed -6 I/N due to LPI unlicensed operations. Out of 152 LADWP links that were studied, only four FS links were identified to potentially experience degraded performance due to

[1] *See* Comments of Apple Inc., Broadcom Inc., Cisco Systems, Inc., Facebook, Inc., Google LLC, Hewlett Packard Enterprise, Intel Corporation, Marvell Semiconductor, Inc., Microsoft Corporation, Qualcomm Incorporated, and Ruckus Networks, (Feb. 15, 2019) at 18, 35-36.

LPI unlicensed operations. However, all four of these links are in barren areas (*see* slides 25-30) where there are no buildings and thus would be no LPI unlicensed operations.

In discussing the viability of LPI unlicensed operations in the 6 GHz band, we noted that our interference protection analysis is based on publicly available FS link operating parameters in the FCC's ULS database. Our analysis demonstrates that FS receivers have substantial excess design margin. This is particularly true of those operating in urban areas where high concentrations of LPI unlicensed operations will occur. Broadcom separately confirmed this analysis, finding links in urban areas typically are shorter length, have higher margin, and therefore are likely to experience less multipath fade than FS links in barren areas.[2]

Also, as shown in slide 10, more than 10,000 FS links in the FCC's ULS database, which represents one-third of Industrial/Business Pool ("MG") links, employ a diversity antenna, which appears to provide spatial diversity as it operates at the same frequency but at a different height from the main receive antenna. Wireless licensees deploy diversity antennas to improve the reliability and resiliency of their wireless links. According to the FCC ULS database, most LADWP links contain a diversity antenna. In addition to spatial diversity, antenna diversity can also be realized via polarization diversity and pattern diversity. Link resiliency also is achieved via fiber optic links and via deployment of redundant ring topologies operating at different wireless frequencies, which many utilities use.[3]

The undersigned companies strongly encourage the Commission to move forward to open the 6 GHz band for unlicensed use as soon as possible in accordance with our Comments and Reply Comments in this proceeding.

Respectfully submitted,

Apple Inc.
Broadcom Inc.
Cisco Systems Inc.
Facebook, Inc.
Google LLC
Hewlett Packard Enterprise
Intel Corporation
Marvell Semiconductor, Inc.
Microsoft Corporation
Qualcomm Incorporated
Ruckus Networks, a Business Segment of CommScope

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[2] *See* March 29, 2019 *Ex Parte* Letter of Broadcom Inc.

[3] *See* Feb. 15, 2019 Comments of the Utilities Technology Council *et al*., Att. at 15 ("Five-9's is accomplished through the use of redundant ring pathways and requires approximately 99.7% availability per path to achieve a combined Five-9's availability per path for the whole telecom system."). The case study assumes 99.99% reliability for all LADWP links, because at the time of this analysis we did not know which links employ redundant ring pathways. This assumption thus provides greater protection than what many of these FS links are designed to achieve, further demonstrating the conservative nature of this case study.

Att.

cc (w/ Att.): FCC OET Meeting Participants

Meeting Participants

Julius Knapp (FCC OET)
Ira Keltz (FCC OET)
Bahman Badipour (FCC OET)
Navid Golshahi (FCC OET)*
Michael Ha (FCC OET)
Syed Hasan (FCC OET)*
Paul Murray (FCC OET)
Nicholas Oros (FCC OET)
Barbara Pavon (FCC OET)
Aspasia Paroutsas (FCC OET)
Jamison Prime (FCC OET)
Hugh Van Tuyl (FCC OET)
Gregory Callaghan (FCC OET)

Dan Mansergh, Apple Inc.*
Chris Szymanski, Broadcom Inc.*
Mary Brown, Cisco Systems Inc.
Peter Ecclesine, Cisco Systems Inc.*
Thomas Navin, Facebook, Inc.
Alan Norman, Facebook Inc.*
Nihar Jindal, Google LLC*
Megan Stull, Google LLC*
Raymond Hayes, Google LLC*
Chuck Lukaszewski, Hewlett Packard Enterprise*
David Horne, Intel Corporation*
Hassan Yaghoobi, Intel Corporation*
Yi-Ling Chao, Marvell Semiconductor, Inc.*
Paula Boyd, Microsoft Corporation
John Kuzin, Qualcomm Incorporated
Yash Patel, Qualcomm Incorporated
Tevfik Yucek, Qualcomm Incorporated
Stuart Kerry, Ruckus Networks, a Business Segment of CommScope*

* Participated via telephone

6 GHz Spectrum Sharing:
Los Angeles Dep't of Water & Power Interference Protection Case Study

July 2, 2019

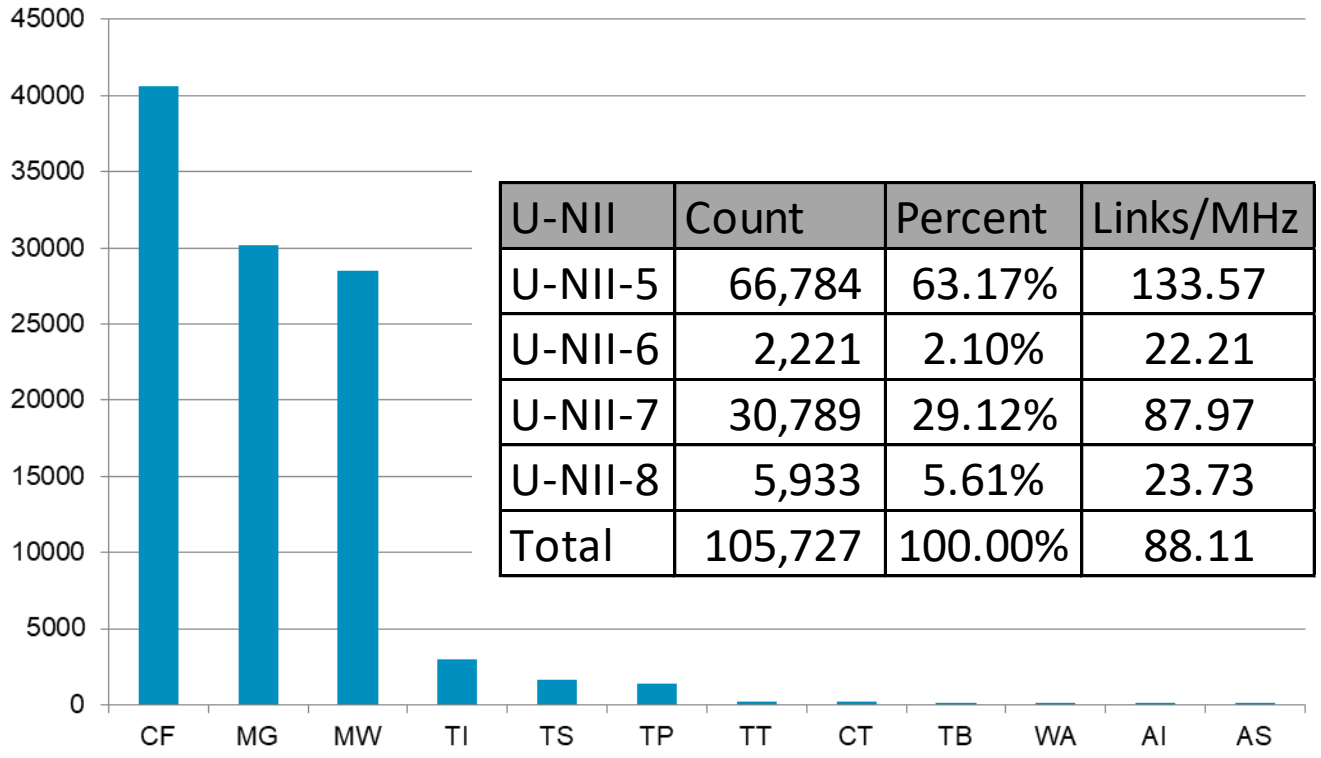
Agenda

- Review of Microwave Industrial/Business Pool Fixed Links in FCC's public database, ULS (Universal Licensing System)
- Overview of Interference Analysis used for Case Study
- Los Angeles Department of Water and Power
  - Interference Protection Case Study
- Next Steps

ULS Review (MG Links)

5925-7125 MHz ULS Data

- 105,727 Links in ULS as of 01/23/2019
  - 93.94% of links attributed to three services
  - Does not include CARS links from COALS Database



U-NII	Count	Percent	Links/MHz
U-NII-5	66,784	63.17%	133.57
U-NII-6	2,221	2.10%	22.21
U-NII-7	30,789	29.12%	87.97
U-NII-8	5,933	5.61%	23.73
Total	105,727	100.00%	88.11

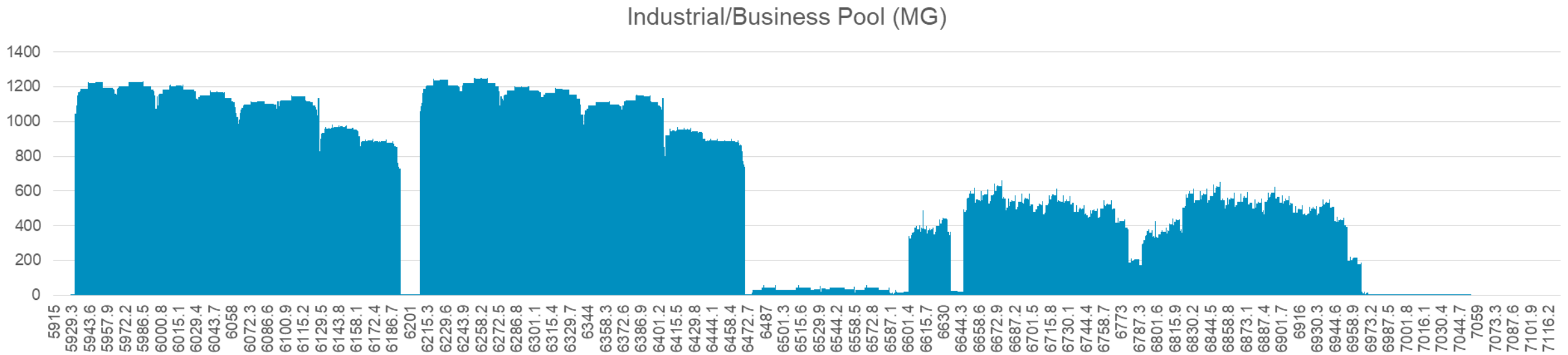
Code	Description	Regulation
AI	Aural Intercity Relay	BAS, Part 74
AS	Aural Studio Transmitter Link	BAS, Part 74
CF	Common Carrier Fixed Point to Point Microwave	Part 101
CT	Local Television Transmission	Part 101, Subpart J
MG	Microwave Industrial / Business Pool	Part 101, Eligibility Part 90
MW	Microwave Public Safety Pool	Part 101, Eligibility Part 90
TB	TV Microwave Booster	BAS, Part 74
TI	TV Intercity Relay	BAS, Part 74
TP	TV Pickup	BAS, Part 74
TS	TV Studio Transmitter Link	BAS, Part 74
TT	TV Translator Relay	BAS, Part 74
WA	Microwave Aviation	Part 101, Eligibility Part 87

Utilities links are typically authorized under Microwave Industrial / Business Pool (MG)

MG Assigned Frequencies

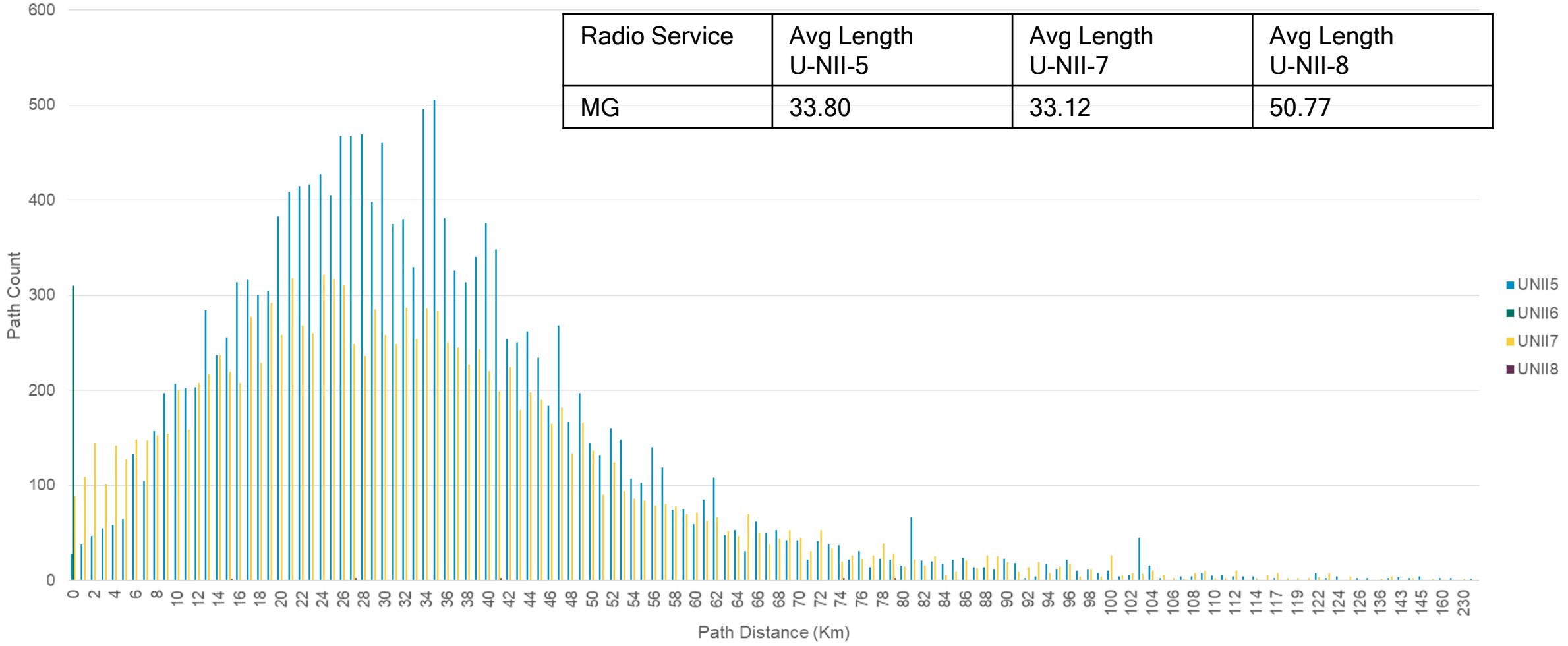
- Over 55% of links are in the U-NII-5 range
- Fewer links in the U-NII-7 sub-band, but links per MHz ratio in that sub-band is higher

U-NII	Count	Percent	Links/MHz
U-NII-5	16,809	55.66%	33.62
U-NII-6	310	1.03%	3.10
U-NII-7	13,070	43.28%	37.34
U-NII-8	9	0.03%	0.04
Total	30,198	100.00%	25.17



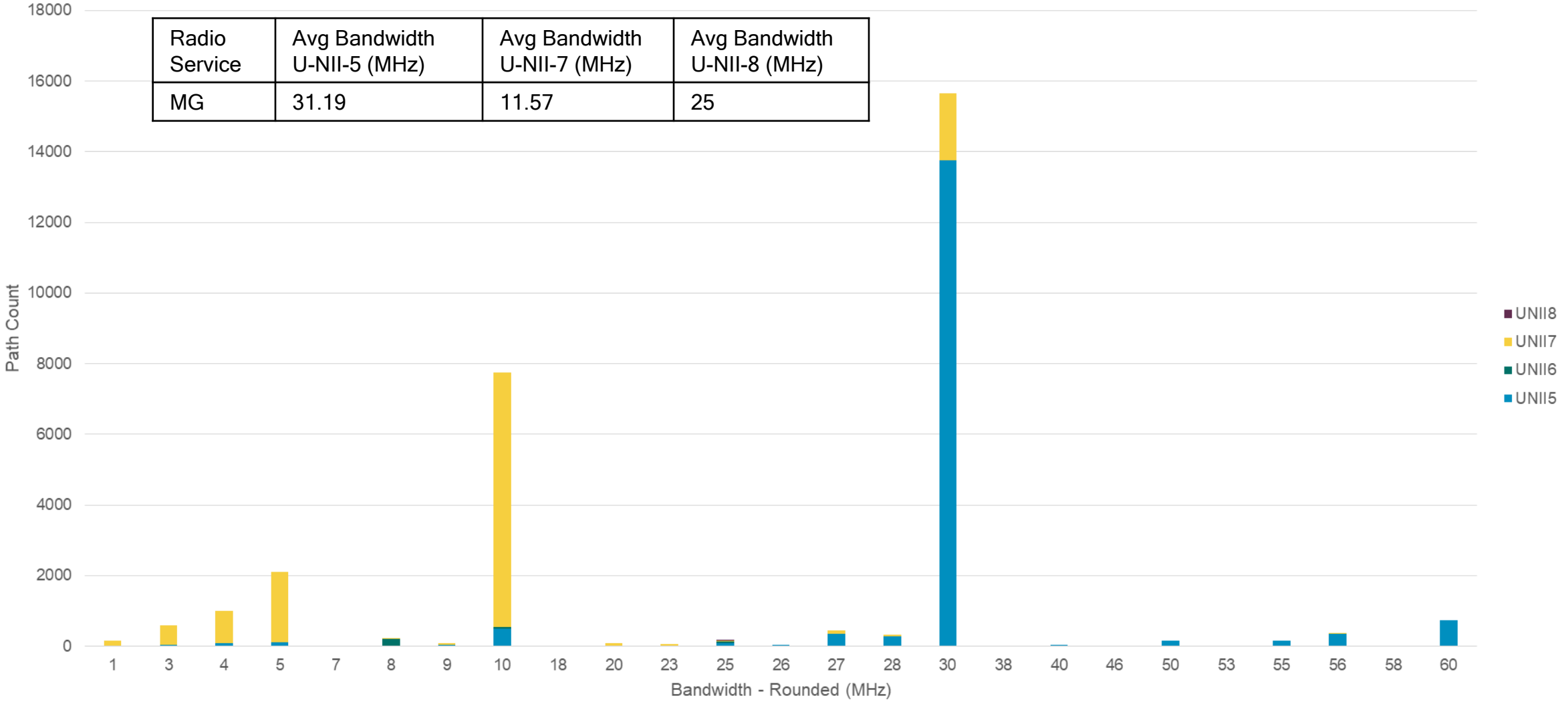
Industrial/Business Pool (MG) Segment Lengths

Radio Service	Avg Length U-NII-5	Avg Length U-NII-7	Avg Length U-NII-8
MG	33.80	33.12	50.77



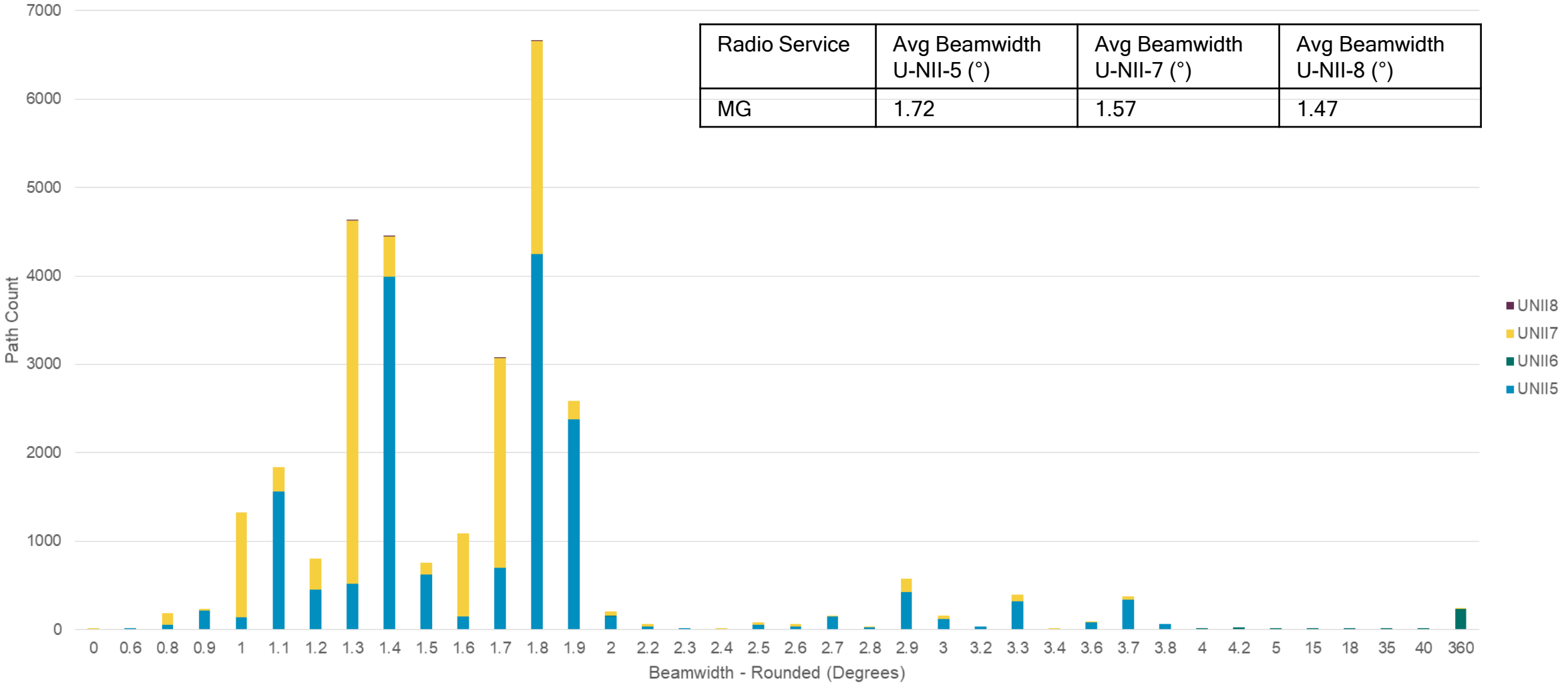
Industrial/Business Pool (MG) Bandwidth (MHz)

Radio Service	Avg Bandwidth U-NII-5 (MHz)	Avg Bandwidth U-NII-7 (MHz)	Avg Bandwidth U-NII-8 (MHz)
MG	31.19	11.57	25



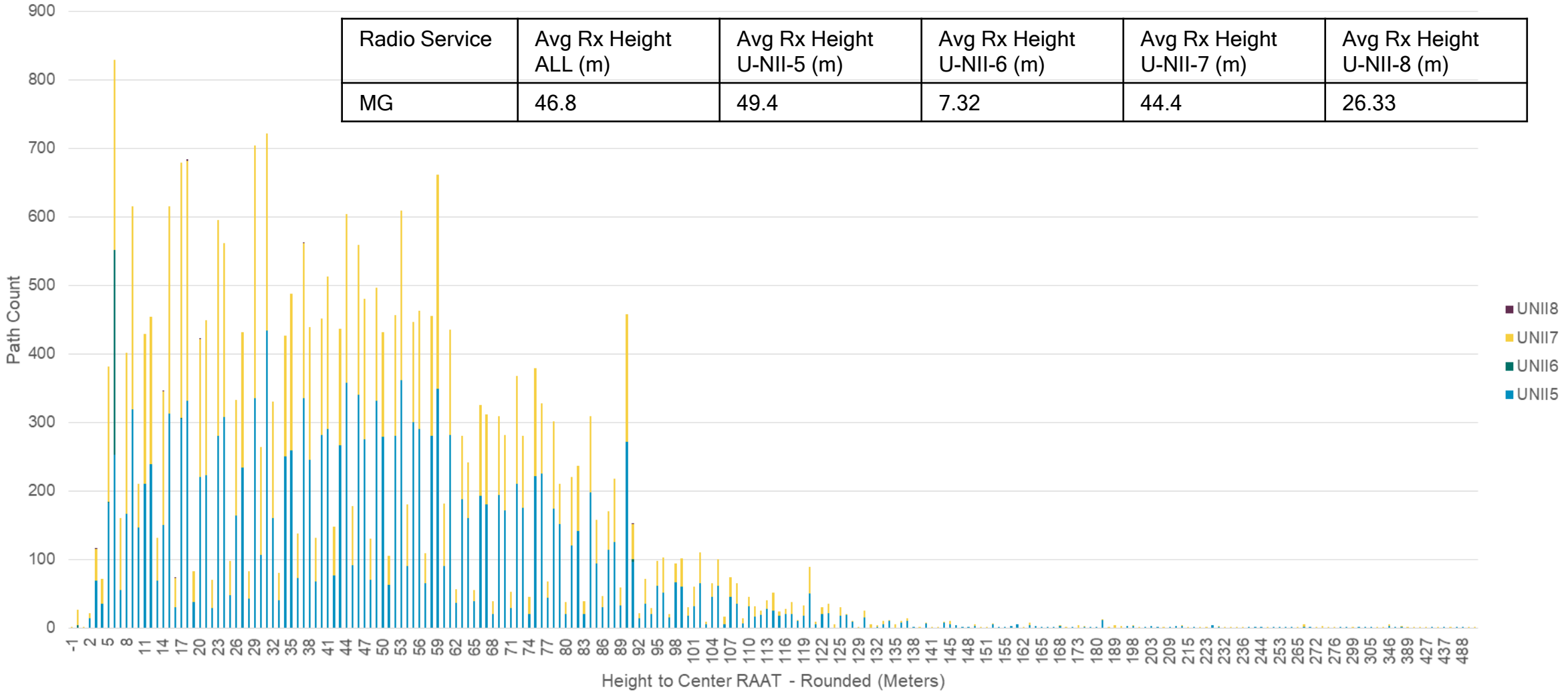
Industrial/Business Pool (MG) Beamwidth (Degrees)

Radio Service	Avg Beamwidth U-NII-5 (°)	Avg Beamwidth U-NII-7 (°)	Avg Beamwidth U-NII-8 (°)
MG	1.72	1.57	1.47



Industrial/Business Pool (MG) Rx Height to Center RAAT

Radio Service	Avg Rx Height ALL (m)	Avg Rx Height U-NII-5 (m)	Avg Rx Height U-NII-6 (m)	Avg Rx Height U-NII-7 (m)	Avg Rx Height U-NII-8 (m)
MG	46.8	49.4	7.32	44.4	26.33



Diversity Antennas Listed in ULS

- 33.29% (10,055) of all MG FS Links have spatial diversity antennas, which helps mitigate multipath fading

Radio Service	Paths w/ Diversity ALL (m)	Paths w/ Diversity U-NII-5 (m)	Paths w/ Diversity U-NII-6 (m)	Paths w/ Diversity U-NII-7 (m)	Paths w/ Diversity U-NII-8 (m)
CF	13,591 (33.47%)	12,137 (34.06%)	2 (40%)	1,424 (29.32%)	28 (23.93%)
MG	10,055 (33.29%)	6,176 (36.72%)	-	3,875 (29.65%)	4 (44.44%)
MW	6,998 (24.54%)	4,701 (32.78%)	-	2,254 (17.53%)	43 (44.33%)
TI	120 (4.05%)	-	-	-	120 (4.05%)
TS	94 (5.66%)	-	-	-	94 (5.66%)
ALL	**30,858 (29.18%)**	**23,014 (34.46%)**	**2 (0.09%)**	**7,553 (24.53%)**	**289 (4.87%)**

Overview of Interference Analysis used for case study

FS Study Overview

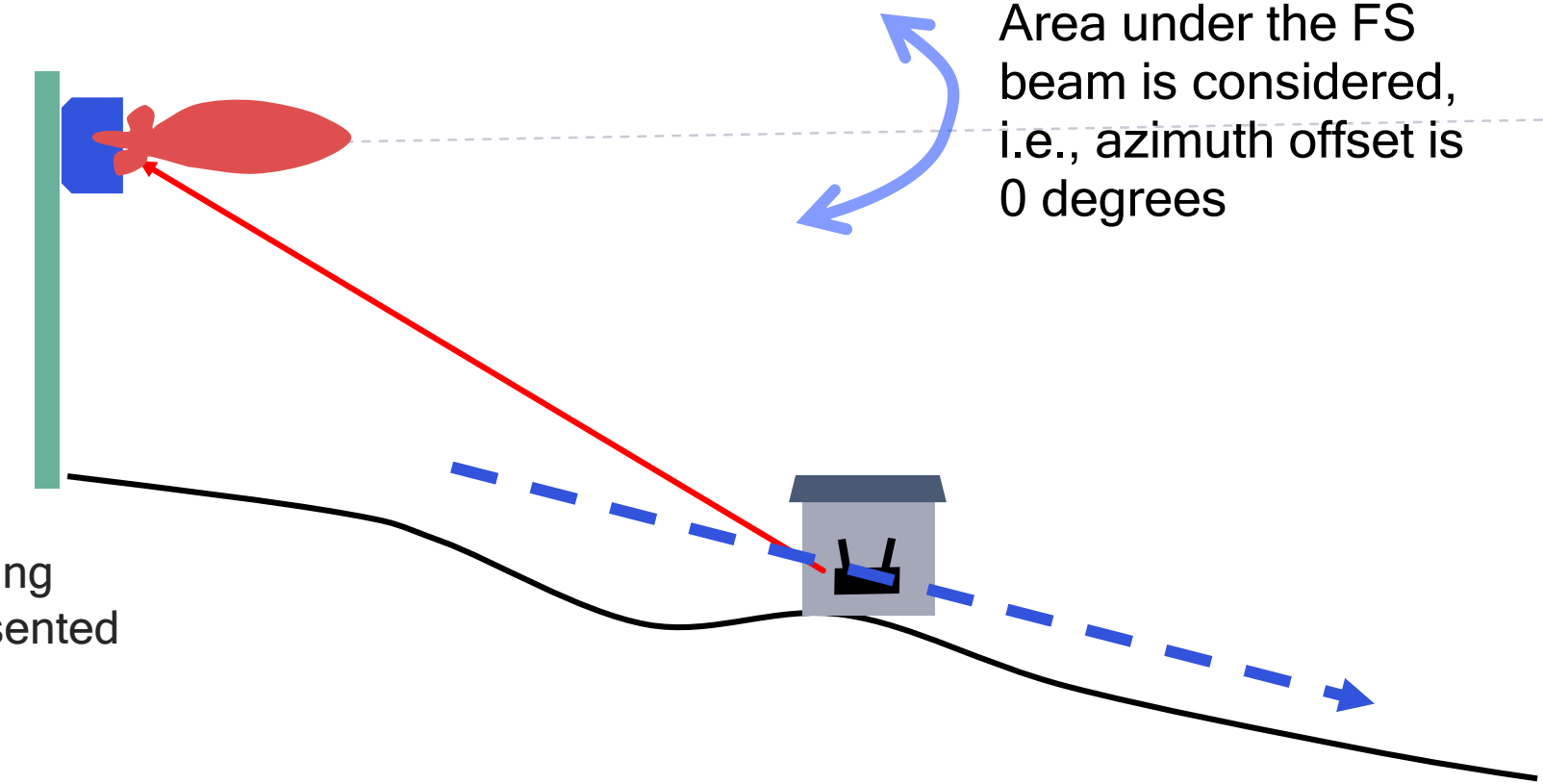
- We have developed a tool that identifies critical RLAN placement areas within 4 km directly below the main beam of an FS receiver that could lead to RLAN operations exceeding -6 dB I/N in a line of sight propagation model
  - 160 measured points at 25 meters intervals from the FS receiver
  - This tool incorporates terrain effects, but it does not include any other clutter
- If there is an area where an RLAN may potentially exceed -6 dB I/N at any measured point, the C/I+N analysis is conducted to assess the potential impact
  - SNReq determination based on the lowest modulation in ULS database for the link
  - Necessary fade margin is calculated using conservative Barnett & Vigant's Method
  - If any point within the critical area is identified as a potential RLAN location that could impact link availability, a review using Google Earth is conducted
- This time and labor intensive process is best handled on discrete data sets

Interference Model Assumptions & Geometry

- Wi-Fi Assumptions
  - 80 MHz Bandwidth
  - 24 dBm Tx power
  - -2 dB Antenna efficiency
  - 3 dB Polarization loss
  - 1.5 meter Antenna height above terrain
  - 2 dB feeder loss for FS link

- Propagation
  - 20 dB building entry loss*
  - Winner II LOS Model

A detailed analysis of RLANs operating inside high-rise buildings will be presented in an upcoming FCC meeting



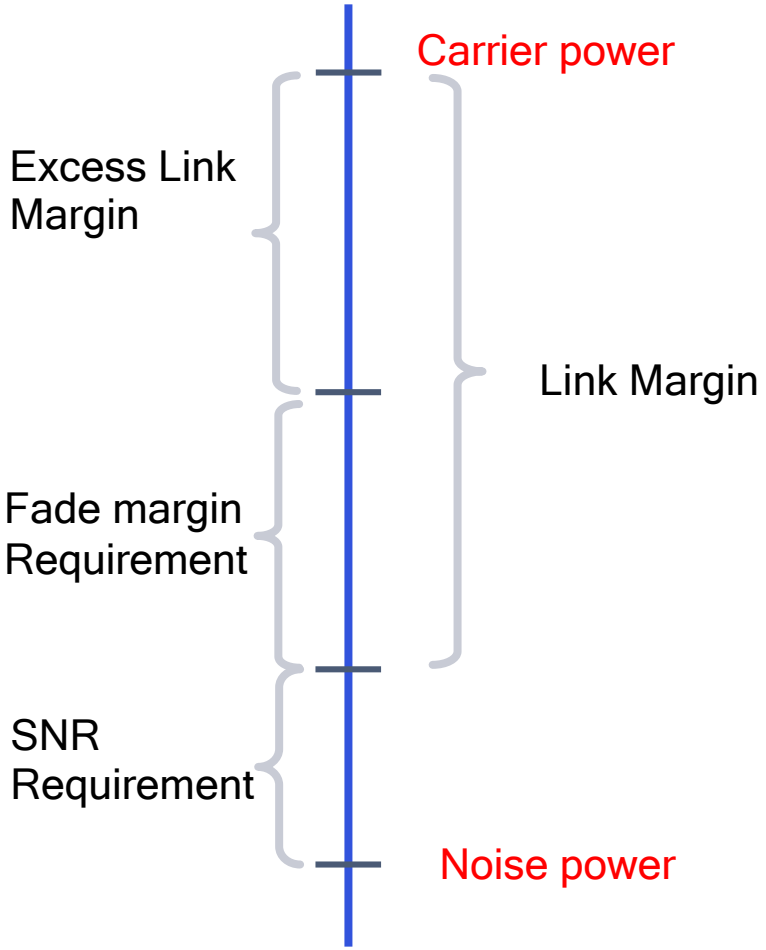
* This is 5 dB more conservative than the lowest building entry loss measurements we have submitted in this docket. See the technical appendix to this Group's NPRM Reply Comments (showing building entry losses between 25 and 70 dB).

Interference Protection Assessment: I/N Analysis

- The unlicensed device is directly below the FS link boresight, i.e., no azimuth discrimination
- The unlicensed device is moved away from the FS receiver in 25 meters increments
- At each location, the following variables are calculated
  - Angle into the FS receiver & FS antenna gain
  - Pathloss from unlicensed device to FS receiver
- At each 25 meter increment, I/N at the potentially impacted FS receiver is calculated
- All 152 FS link receivers licensed by LADWP in FCC ULS database were analyzed. All required data is publicly available in ULS.

Interference Protection Assessment: C/I Analysis

- C/I Analysis is based on 3 calculations
  - Calculate C/N for each link
  - Calculate SNR requirements to support lowest modulation listed in ULS
  - Calculate minimum fade margin using Barnett & Vigant's Method (assuming uptime requirement is 99.99%[1])
- Link margin is determined via the above calculations
  - The onset of interference begins when the reduction in link margin due to RLAN exceeds the available (calculated) margin



[1] See Feb. 15, 2019 Comments of the Utilities Technology Council et al., Att. at 15 ("Five-9's is accomplished through the use of redundant ring pathways and requires approximately 99.7% availability per path to achieve a combined Five-9's availability per path for the whole telecom system.") Because it was unknown at the time of this analysis whether redundant ring pathways are used by these links, 99.99% reliability for each path was assumed. This assumption provides greater protection than what many of these FS links are designed to achieve, further demonstrating the conservative nature of this case study.

Interference Protection Assessment: Additional Review

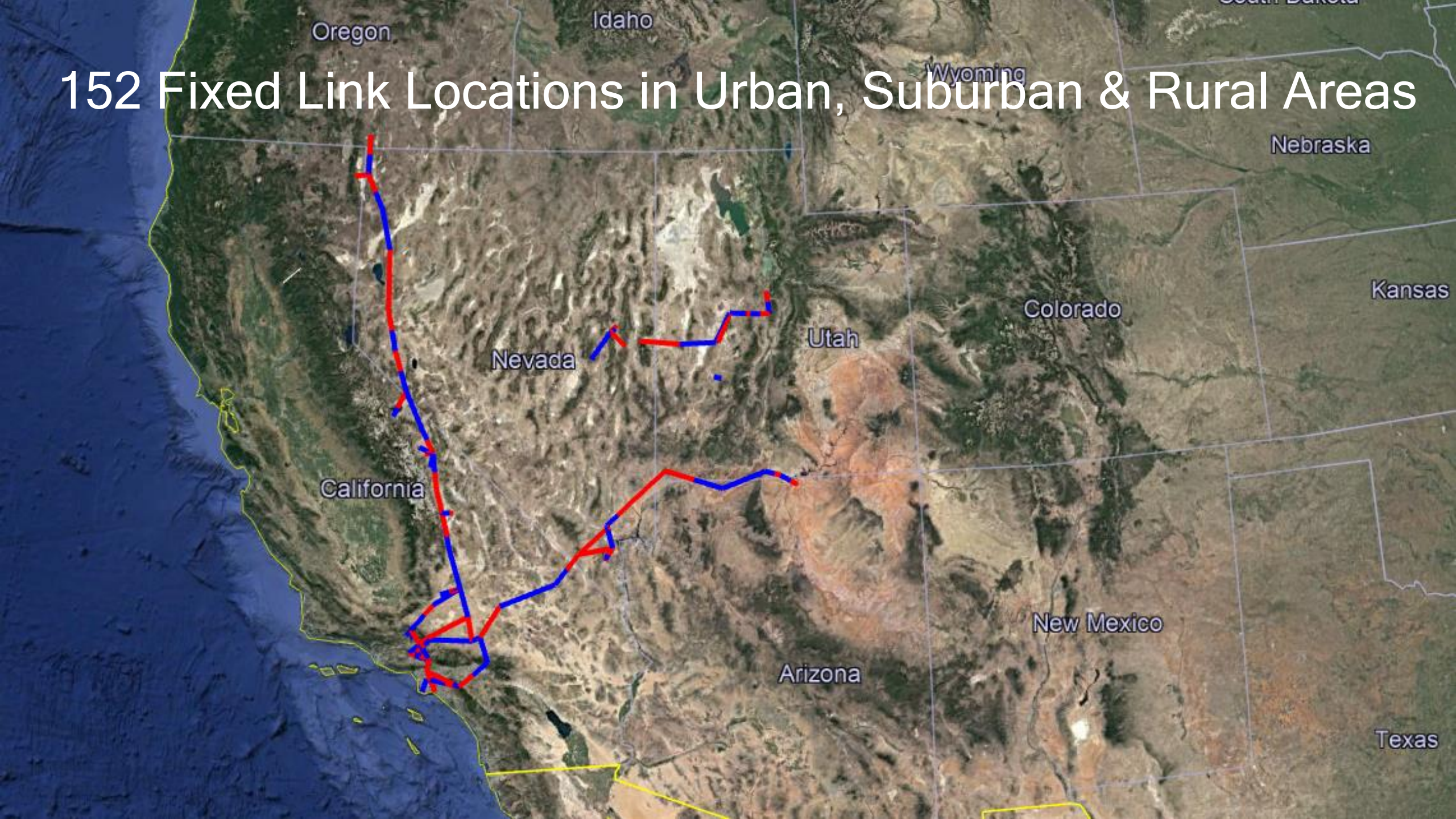
- After identifying those areas where an RLAN placement could potentially create a risk of harmful interference, further study is conducted:
  - To determine whether the link employs diversity antennas, which many FS links already use to mitigate multipath fading
  - To further quantify the risk of harmful interference, a thorough link review is conducted using Google Earth

Case Study:
Los Angeles Department of Water & Power FS Links

Introduction

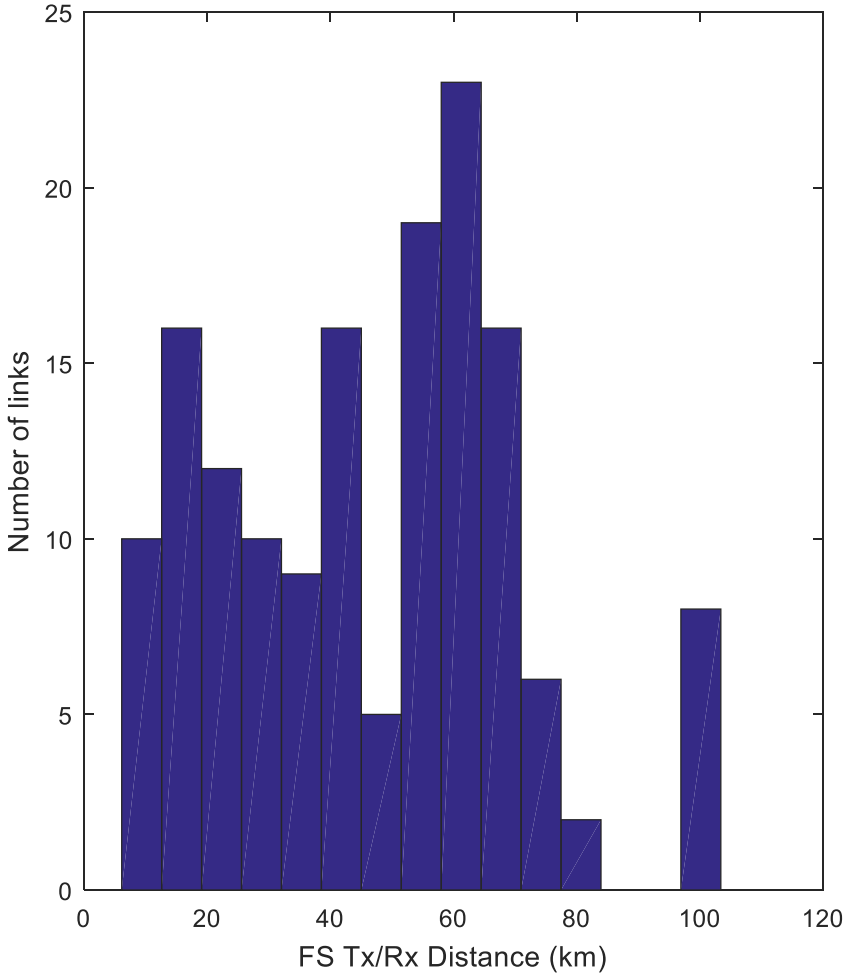
- Analysis of the potential impact of RLAN devices under the main beam and within 4 km of the FS receive antenna for all 152 unique fixed links operated by Los Angeles Dep't of Power and Water (in FCC ULS database as of January 2019)
  - Study includes only low-power indoor (LPI) devices
    - Outdoor and higher-power devices will be coordinated via the proposed Automated Frequency Coordination (AFC) System
  - Line-of-sight path loss (worst-case) model assumed

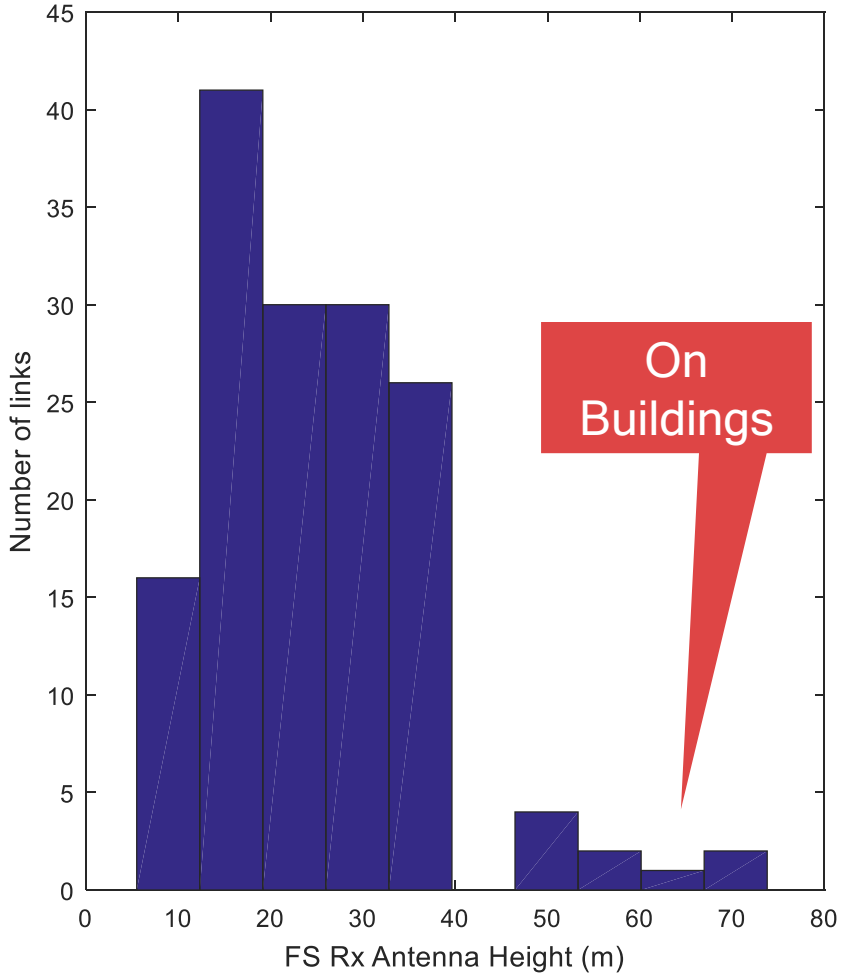
152 Fixed Link Locations in Urban, Suburban & Rural Areas

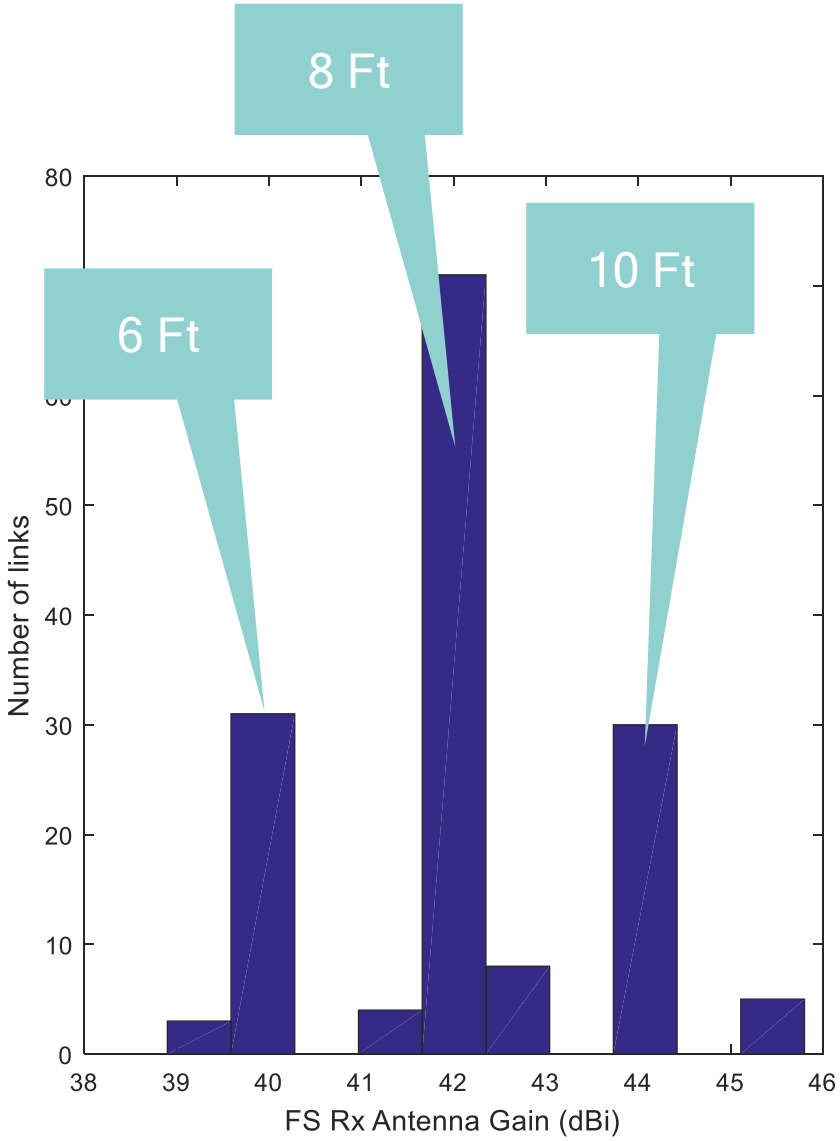


Further Info on the 152 Links per FCC ULS database

Tx/Rx Distance, Rx Antenna Height, Rx Antenna Gain



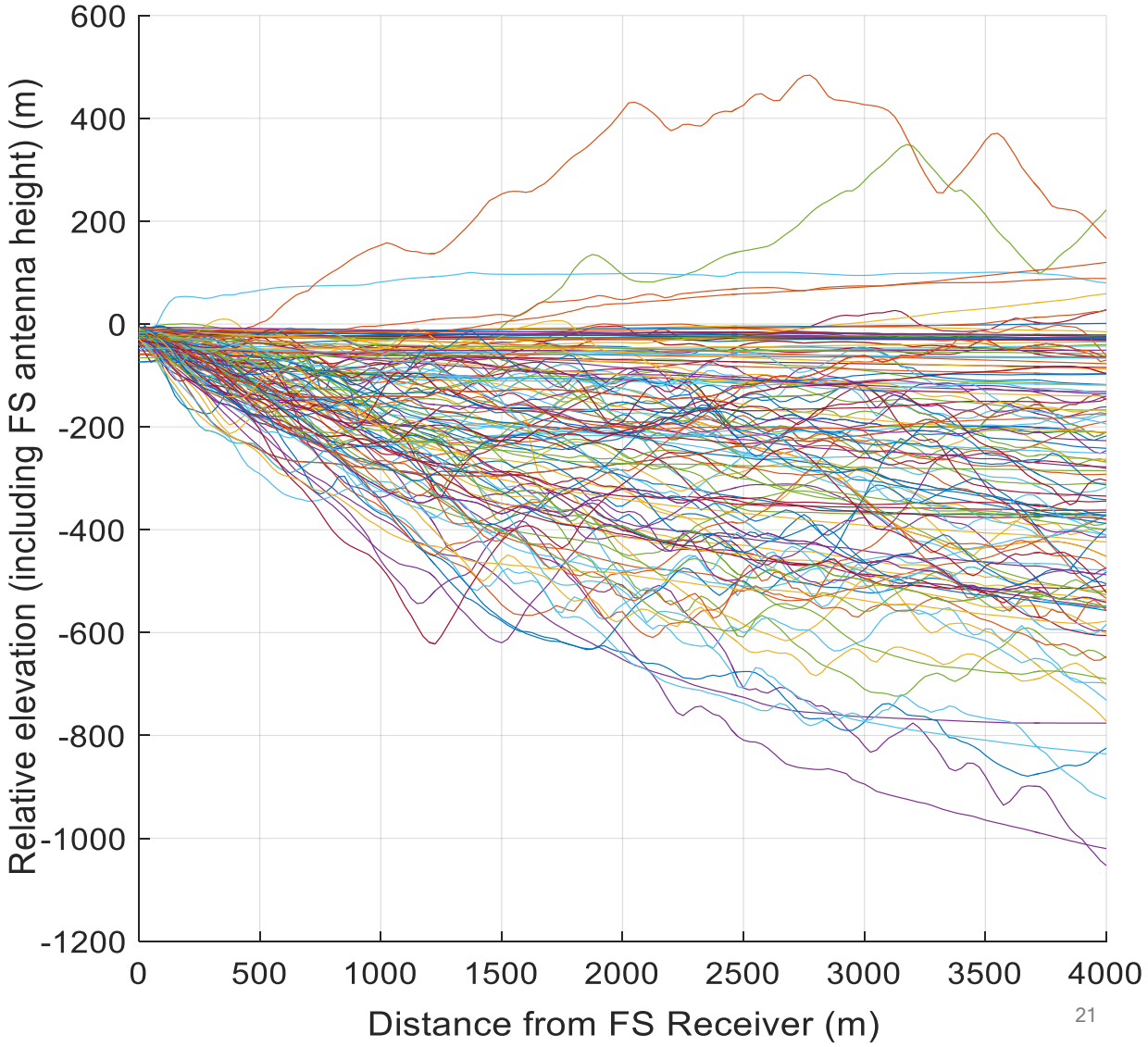




RLAN / FS Heights

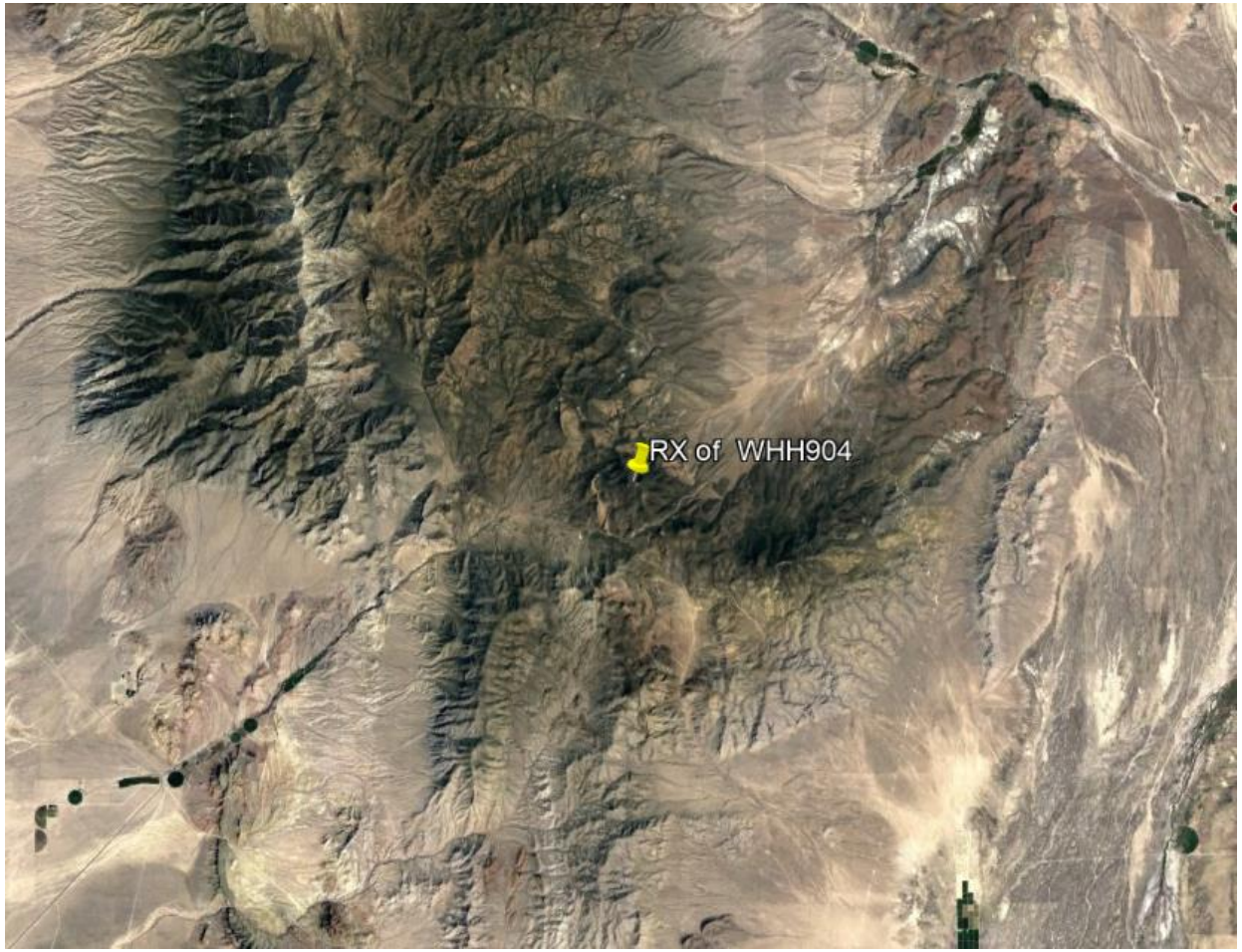
FS Receivers mostly have higher elevation than their surroundings

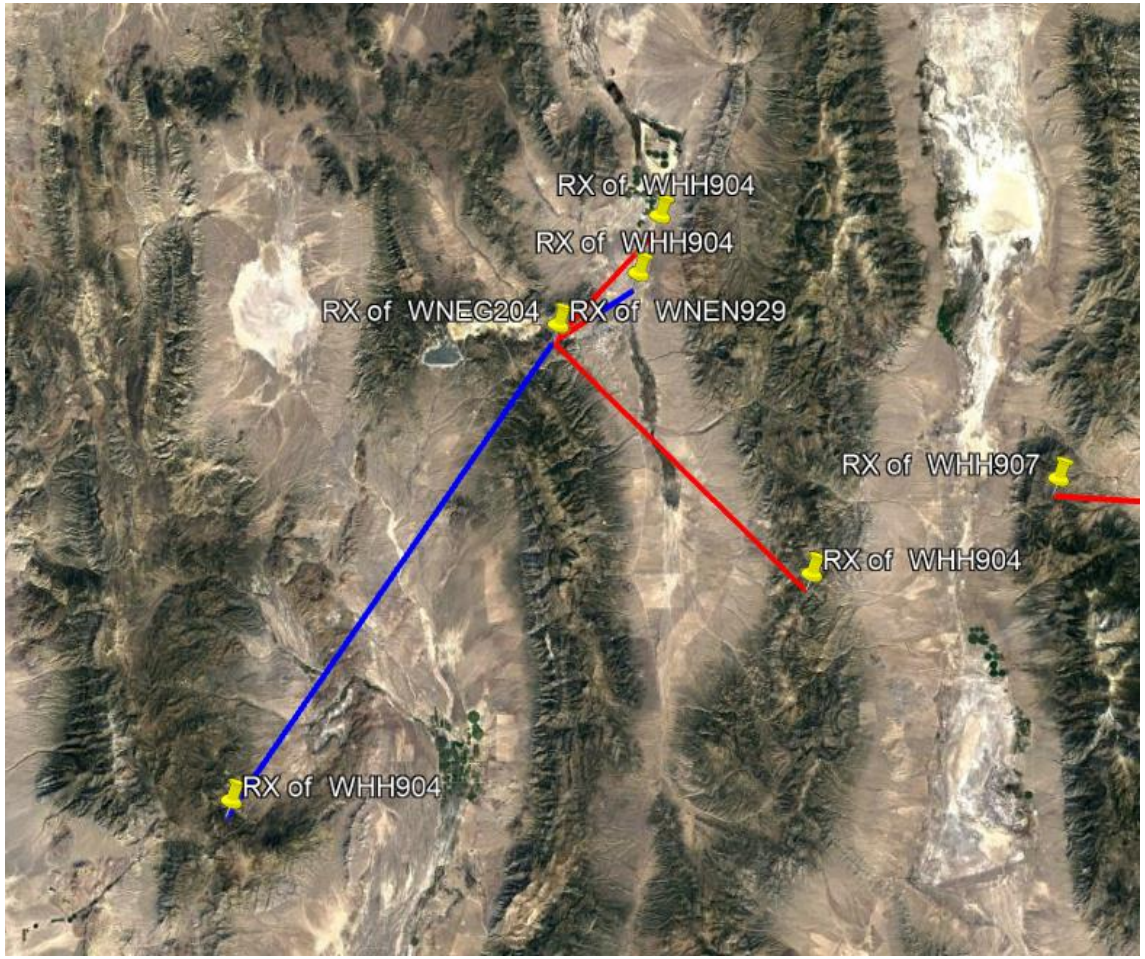
- Figure depicts elevation profiles in the boresight direction for all 152 LADWP links
  - FS receiver antenna height above terrain (HAAT) also is included
- Except for a few cases, all indoor RLANs will be located well below the boresight of the FS receiver
  - This is because FS links are usually installed at the highest point of the surrounding terrain



FS Receiver Locations

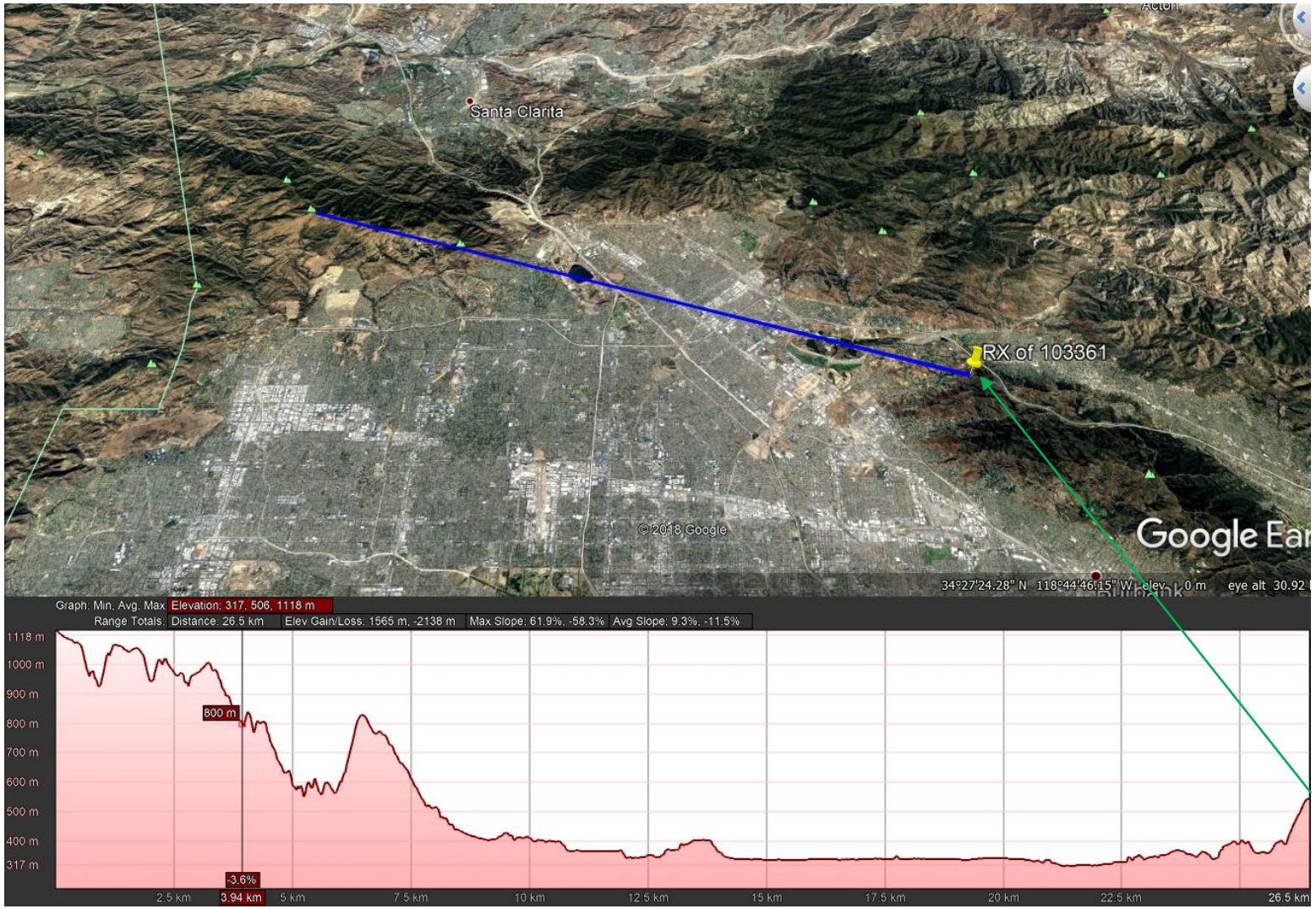
Vast majority of LADWP FS links are on mountaintops and in uninhabited locations





… But Some Span Urban Areas

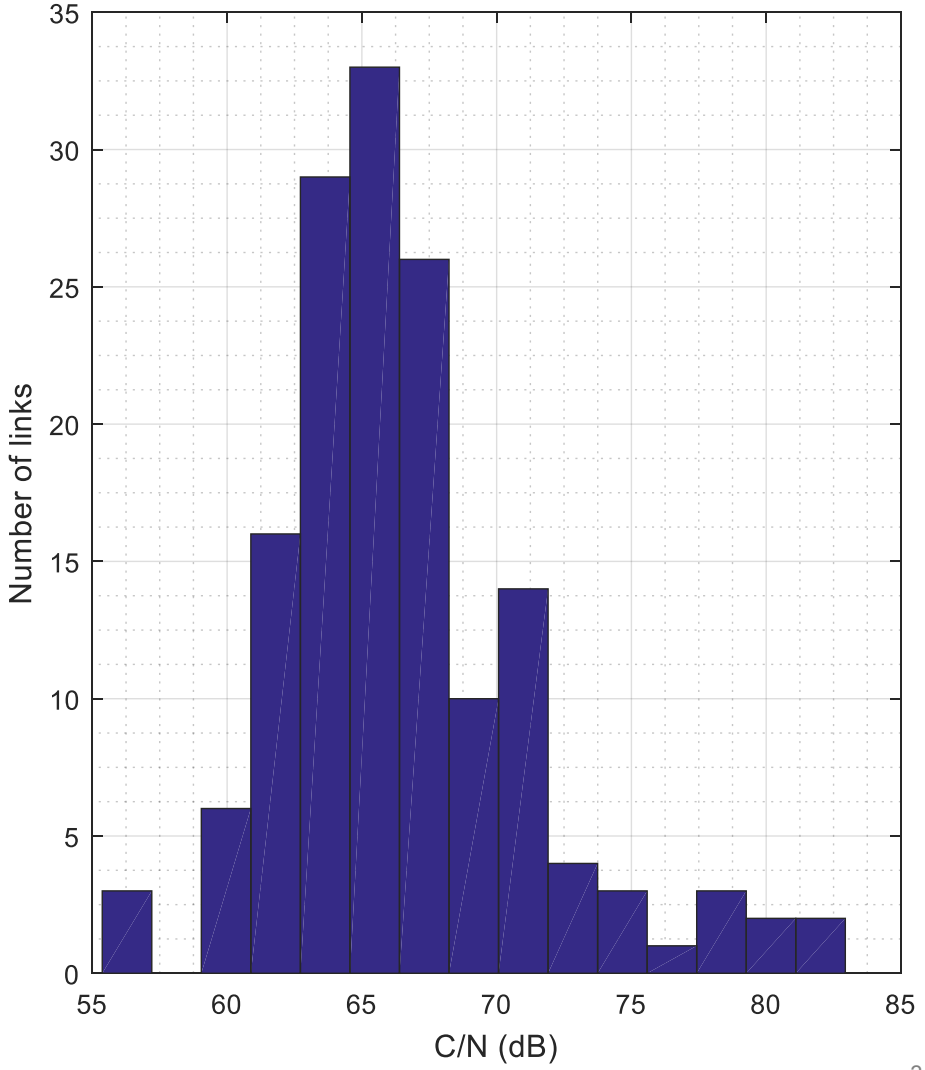
Tx – Rx pair is located high above the residential areas



Available C/N for LA Dep't Power & Water Links

C/N more accurately represents link operating conditions than I/N

- Public FCC ULS database provides:
  - FS transmit power
  - FS receiver antenna model/gain
  - FS transmitter & receiver locations
  - Operating bandwidth
- C/N is calculated based on these parameters
- C/N minus required SNR for specific modulation provides link margin
- Within the 152 links, the lowest C/N is 55 dB, Mean C/N is 67 dB



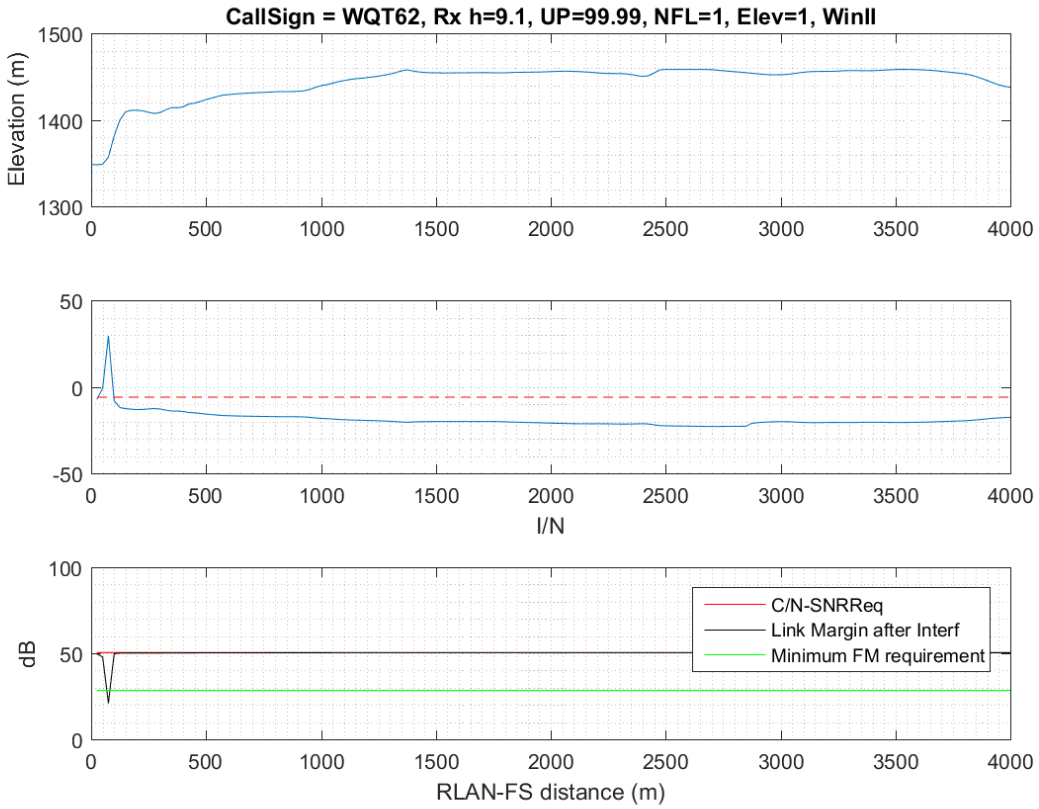
Summary of the LADWP Link Analysis

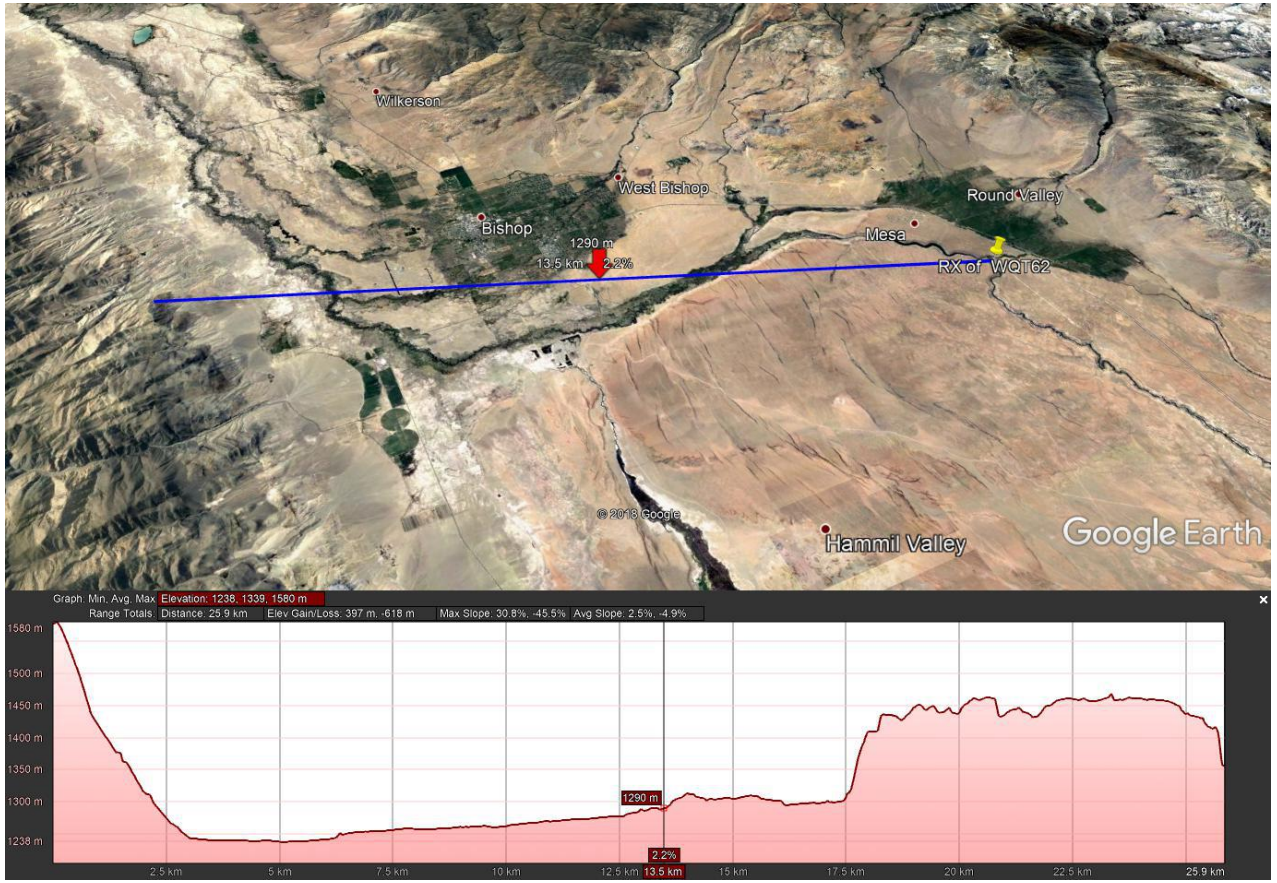
- After simulating the impact of an indoor RLAN placed every 25 m for the first 4 km for all 152 FS links, amounting to 24,320 unique points, we observed
  - 39 links with at least 1 critical area where the model indicated an indoor RLAN (based on the above assumptions) could lead to an I/N exceeding -6 dB
- Conducted a C/I analysis of those 39 links and found four that could potentially experience degraded performance
  - These scenarios are presented in the next slides
  - All 4 links are in un-populated areas, i.e., locations where there is no realistic scenario of an indoor AP
  - Three of the links have diversity antennas, which means "the likelihood of having a fade outage can typically be reduced by a factor of one hundred,"[2] further reducing the need for excess margin
  - The fourth link would not experience harmful interference because it spans a barren area

[2] AT&T Bell Laboratories, *Transmission Systems for Communications*, Page 477, Fifth Ed., 1984

Case 1: WQT62

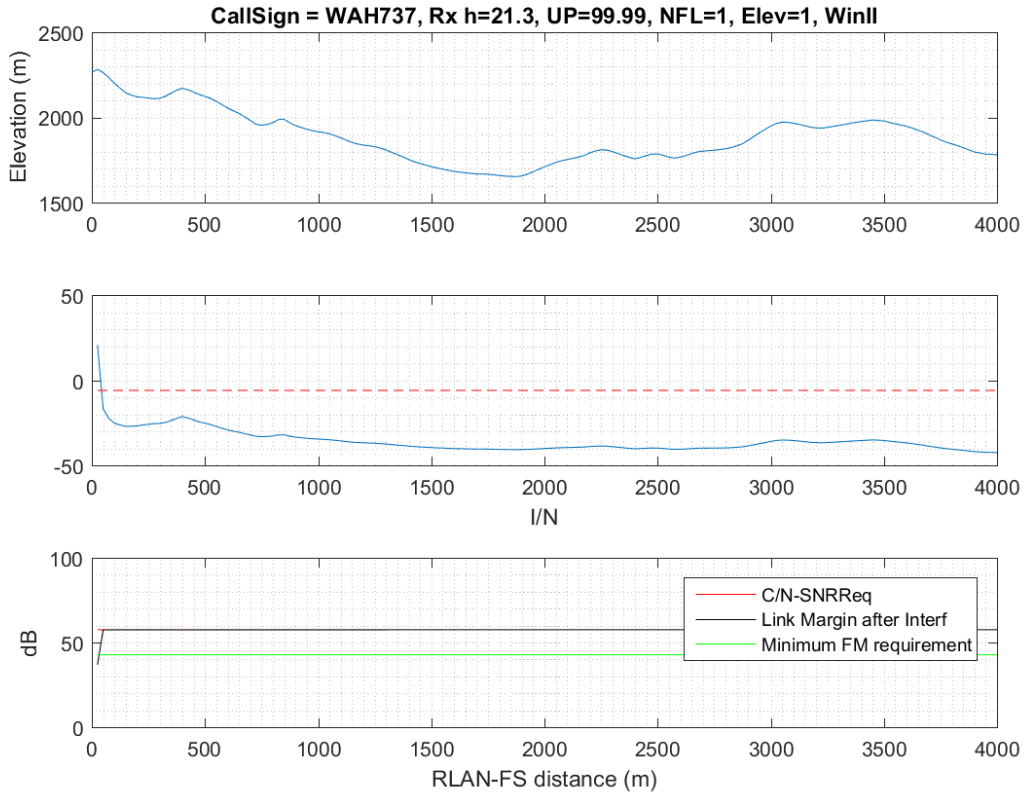
- Receiver appears to be located well below surrounding terrain
- Critical area identified is barren and would not realistically contain indoor low power RLANs

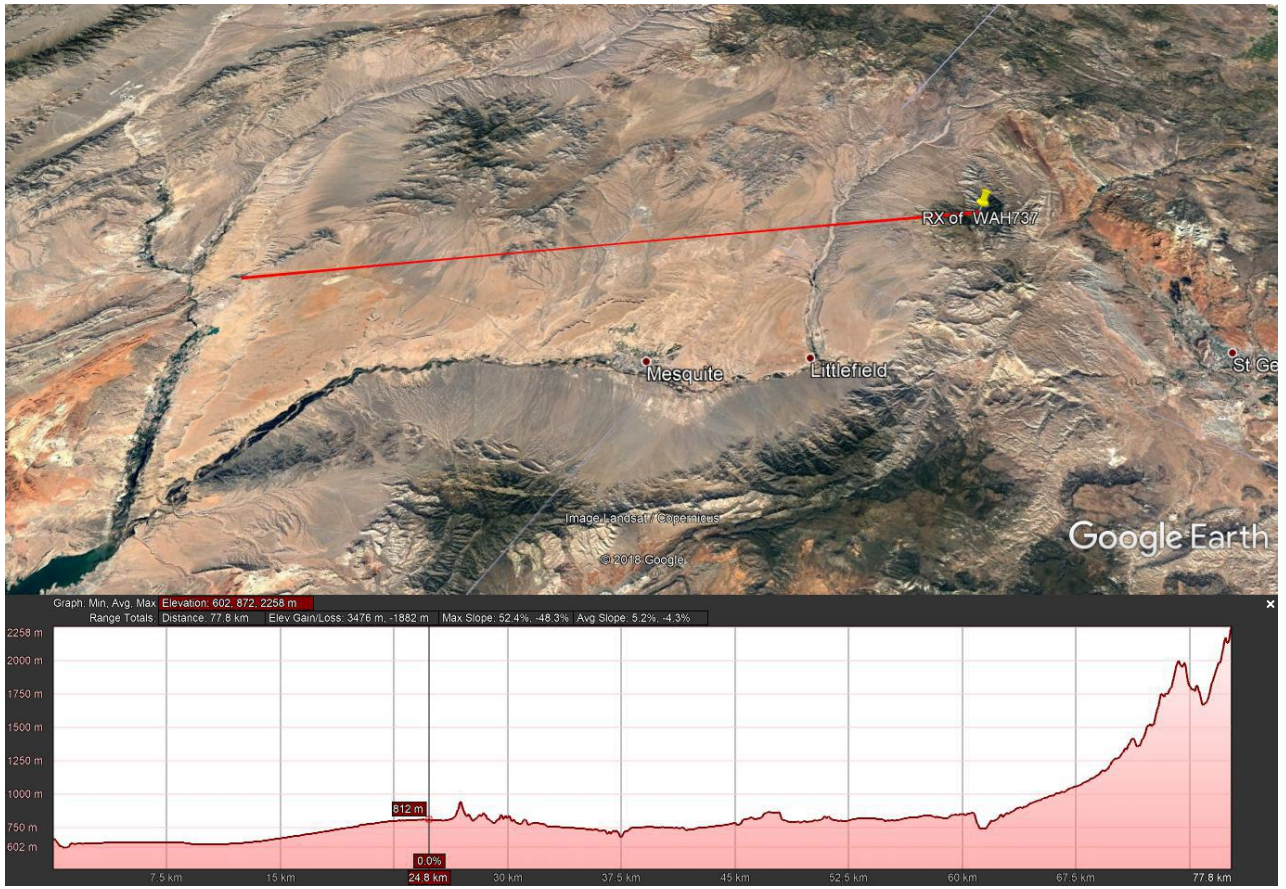




Case 2: WAH737

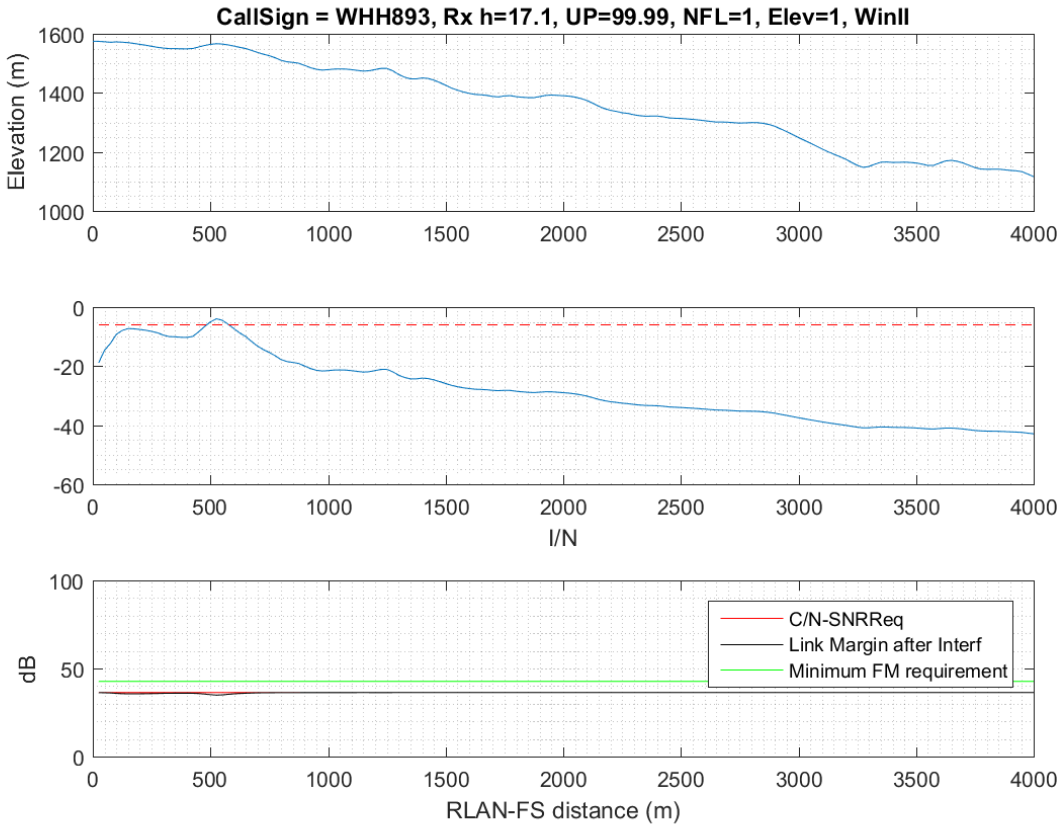
- Critical area identified is barren and would not realistically contain indoor low power RLANs
- Link also employs a diversity antenna, which greatly offsets the risk of link outage because of coincident RLAN interference and deep multipath fade

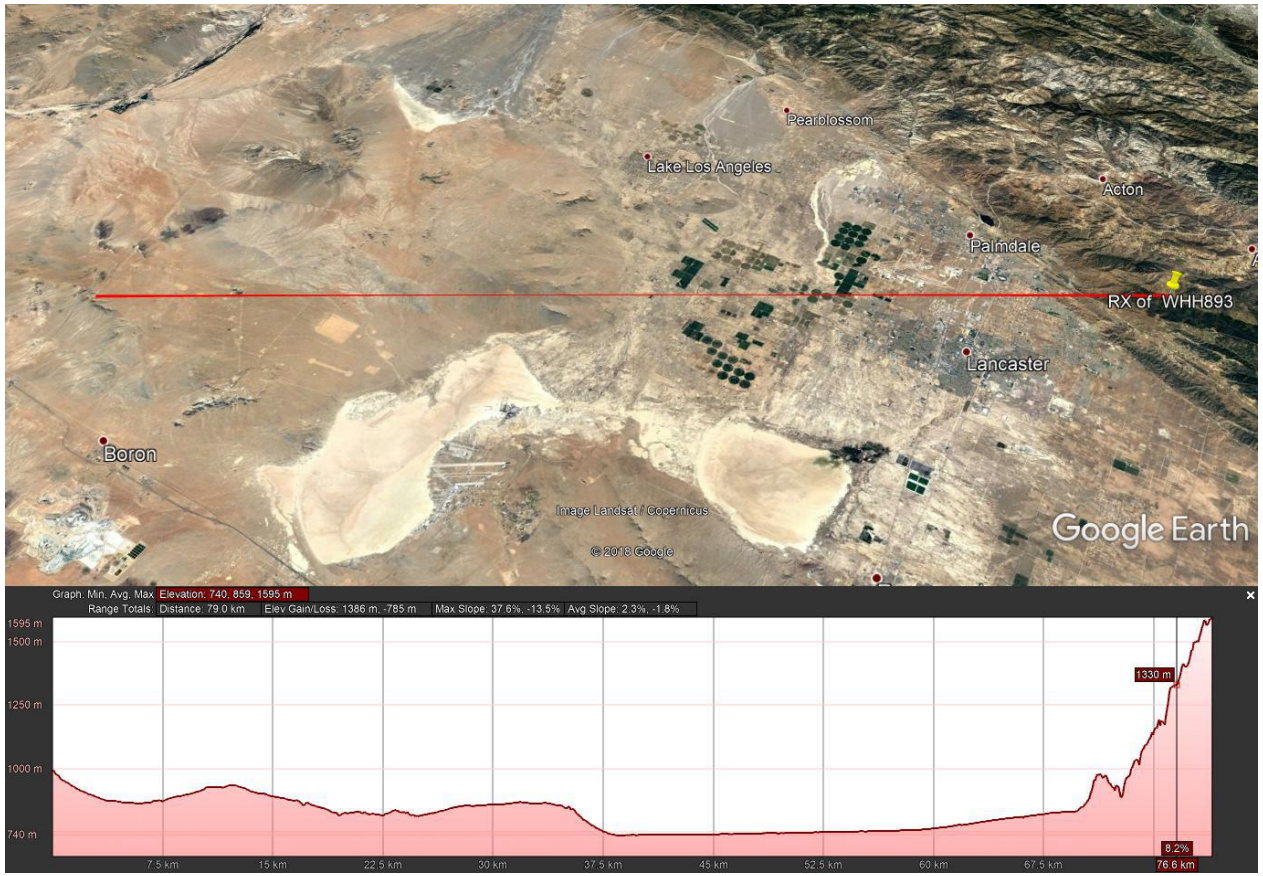




Case 3: WHH893

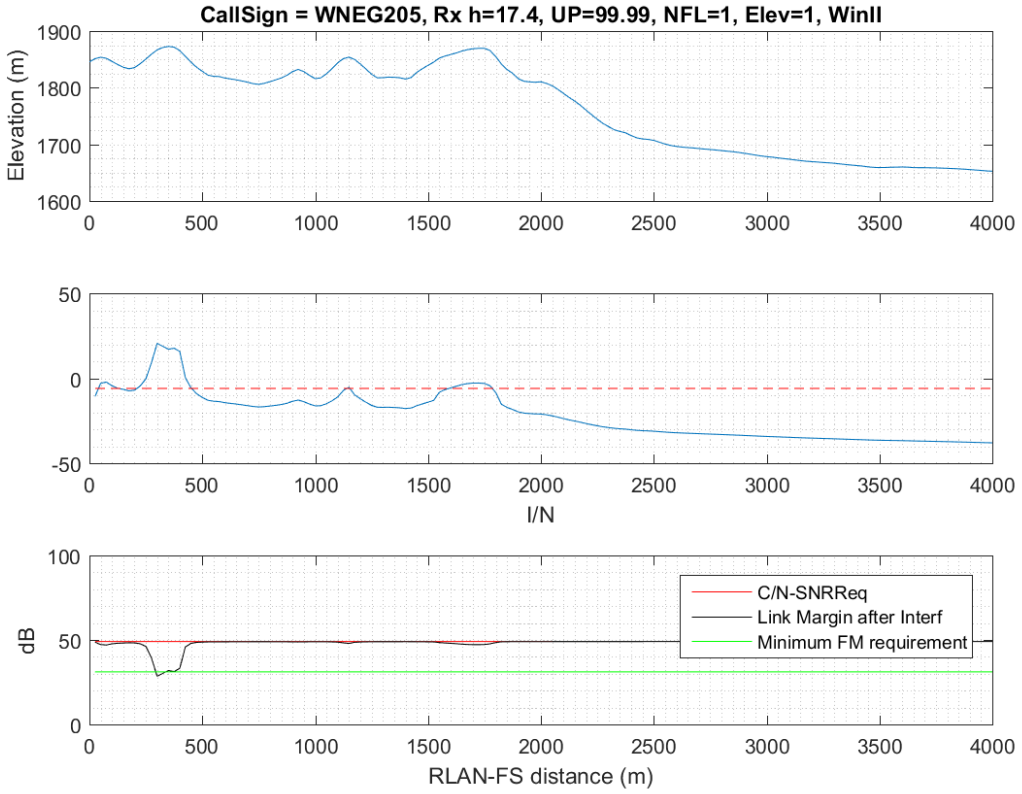
- Very small area where a line-of-sight RLAN could possibly lead to an exceedance of -6 dB I/N
- Link also employs a diversity antenna, which greatly offsets the risk of link outage because of coincident RLAN interference and deep multipath fade

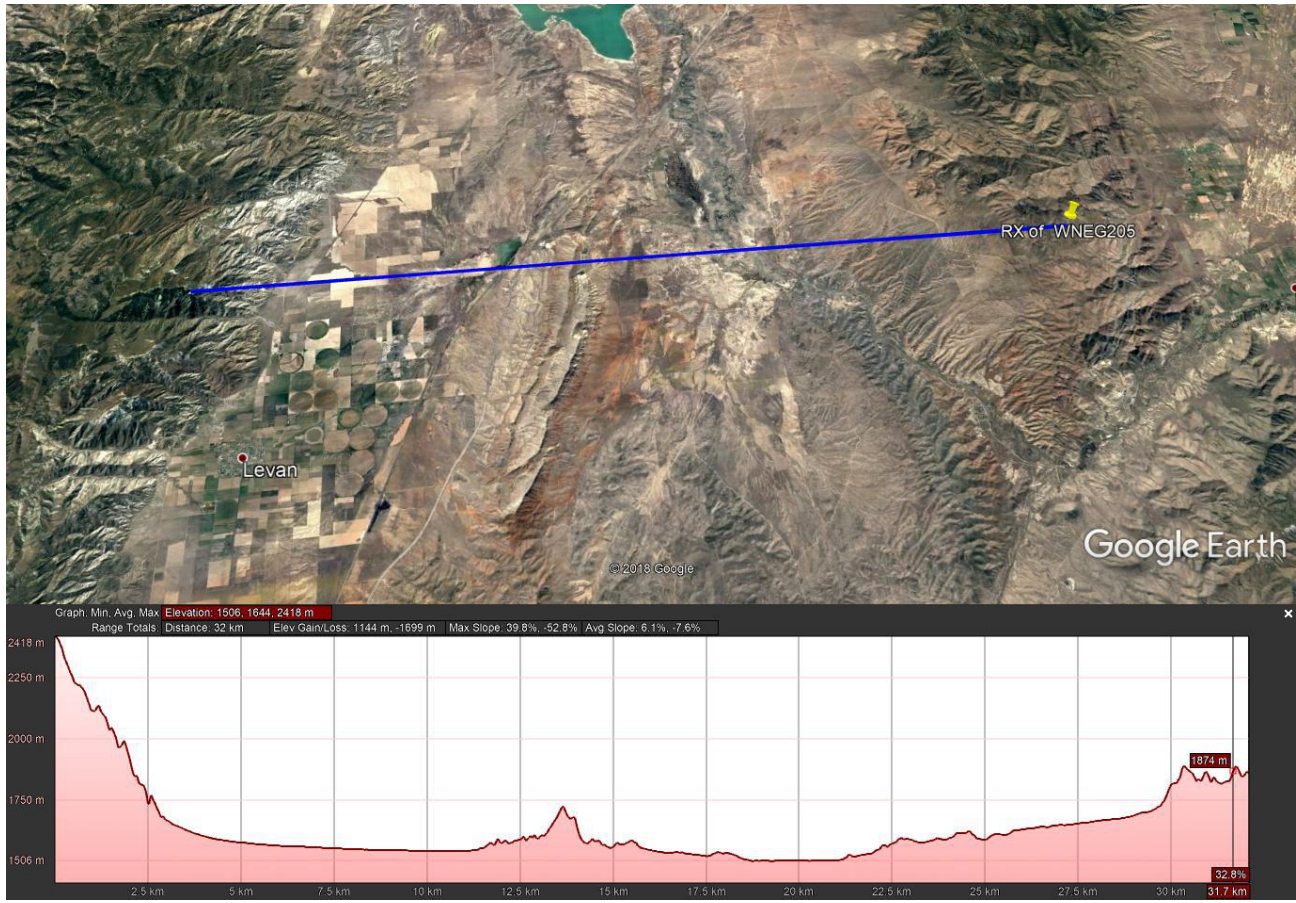




Case 4: WNEG205

- Critical areas are in barren locations where indoor RLANs are unlikely to be located
- Link also employs a diversity antenna, which greatly offsets the risk of link outage because of coincident RLAN interference and deep multipath fade

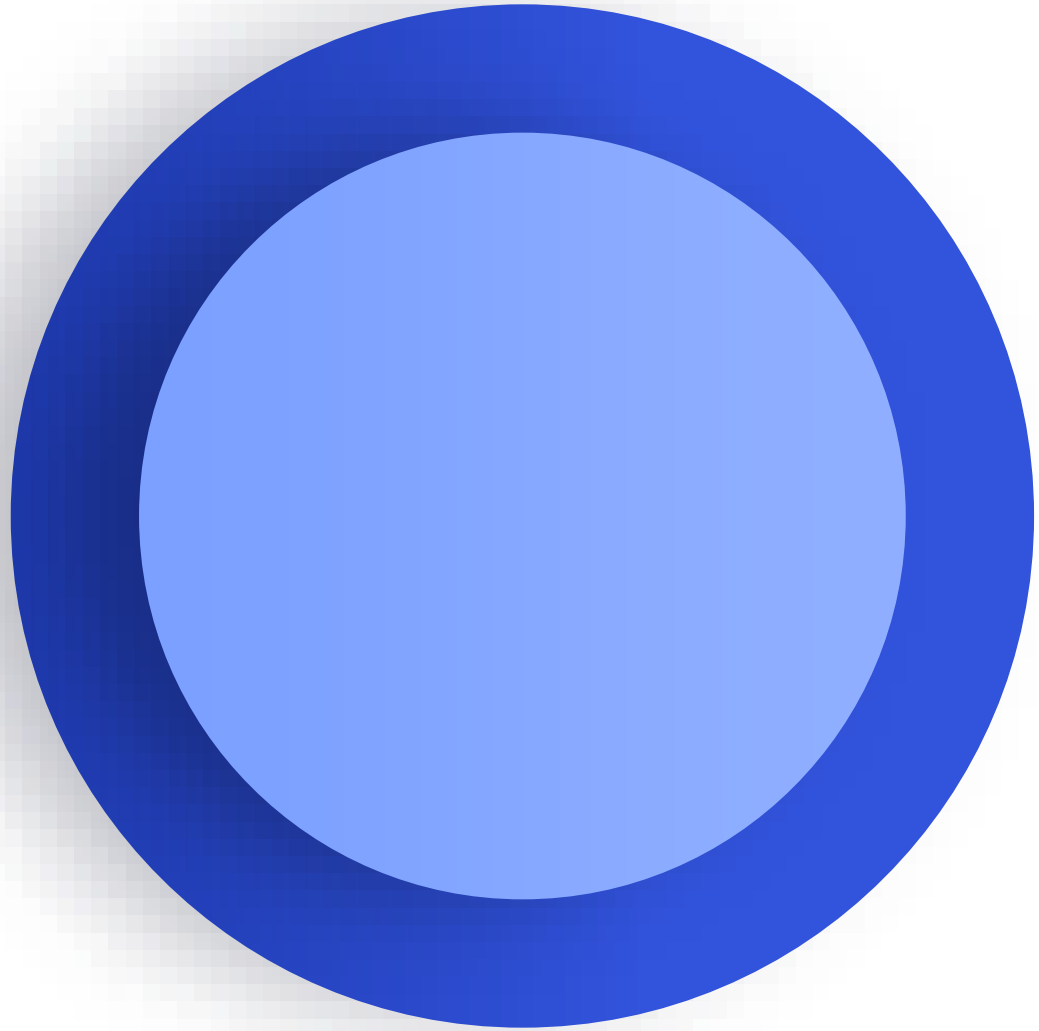




Conclusions

- Foregoing case study of the potential interference from unlicensed low power indoor (LPI) devices to all 6 GHz LADWP FS links demonstrates that harmful interference to any single link is extremely unlikely even in a line-of-sight scenario
- Higher power outdoor unlicensed devices would be managed by the AFC system and would not be granted co-channel access
- This detailed, thorough, and time consuming analysis of the LADWP links, which demonstrates the viability of LPI operations in the 6 GHz band, can be extended to other FCC licensees' FS links

Appendix



Modulations of 4 Links

- WQT62:
  - 1 modulation listed: TCM, (10 MHz)
- WAH737:
  - 3 modulation listed: 256QAM, 64QAM and 16QAM (10 MHz)
  - 16QAM is used in the analysis.
- WHH893:
  - 1 modulation listed: 128 TCM (30 MHz)
- WNEG205:
  - 1 modulation listed: 128 QAM (5 MHz)

Example of Urban Link: WDL56

Note the up-tilt in the receiver antenna